The Systemic Effects of Blood Flow Restriction Training: A Systematic Review

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Introduction

Blood flow restriction (BFR) training has been reported to have benefits in skeletal muscle development (advances in mass and strength). However, there is a lack of understanding of the systemic effects induced. Because BFR involves occlusion of blood flow via pressure cuff/tourniquet, disadvantageous systemic effects on multiple body systems may be observed.

Research demonstrates BFR's ability to promote positive muscular adaptations when combined with low resistance exercise. If specific patient populations (geriatric, medically compromised, etc.) can use BFR with low resistance to improve muscle health without the stress of high intensity training, this may become a valuable training method in clinical practice.

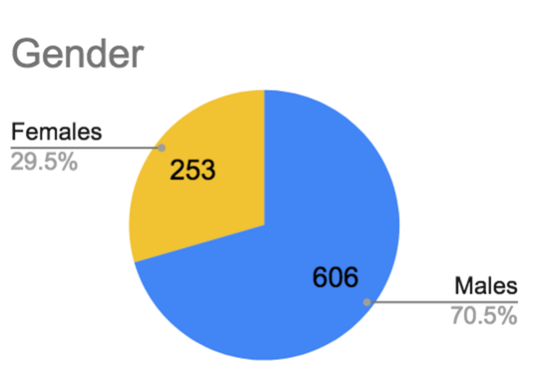
The purpose of this review is to explore the positive and/or negative effects of BFR training on body systems other than local musculoskeletal. This is imperative when determining BFR's role in the future of physical therapy.

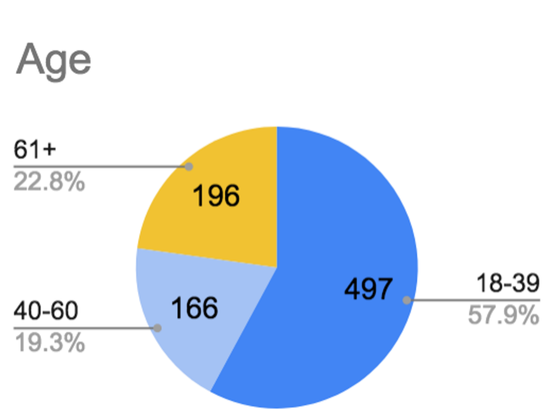
Methods

- Searches completed June 2019, September 2019, and January 2020 from MedLine, ScienceDirect, PubMed, Cochrane Reviews and CINAHL complete
- Search terms used included "blood flow restriction", "occlusion training", "restriction of blood flow", "systemic effects", "blood flow restriction training", "partial occlusion", and "effect or effects"
- Exclusion criteria: research that focused on local musculoskeletal changes, articles that did not originate from a peer-reviewed journal, a level of evidence weaker than 2 according to the CEBM levels of evidence, and PEDro scores less than 4

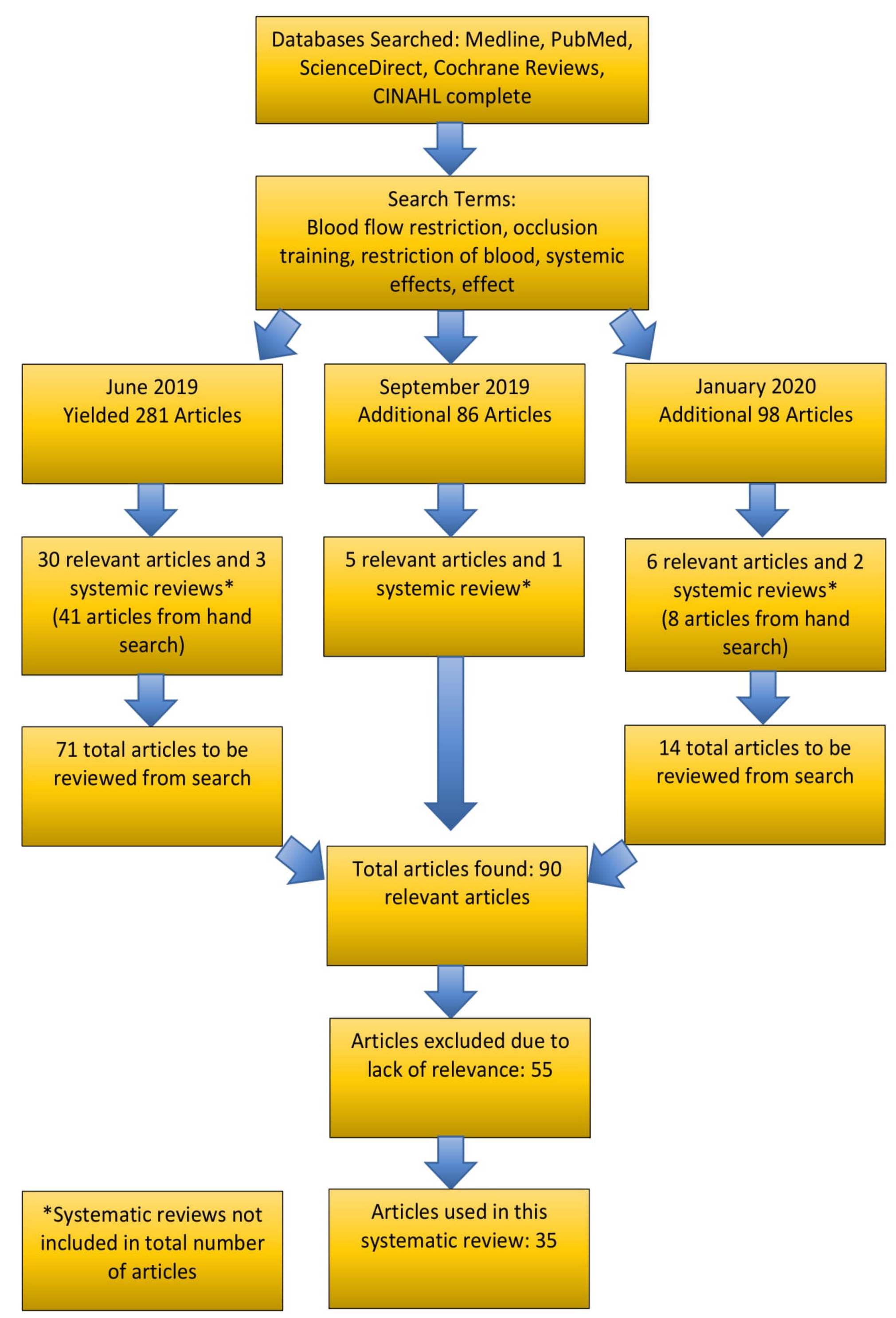
Results

- June 2019: 2299 total results. Assessment of title/ abstract yielded 281 articles. 30 articles and 3 systematic reviews deemed appropriate; hand search yielded 41 appropriate articles. 71 total articles.
- September 2019: 86 new articles; 5 deemed relevant
- January 2020: 98 new results; 6 articles and 1 systematic review determined appropriate; hand search yielded 8 appropriate articles. 14 total articles.
- 90 total articles reviewed. 55 were excluded due to lack of relevance. A total 35 articles use in this systematic review.
- Demographics:





Article Search Strategy



- Level of Evidence: ≥ 2
- PEDro Scores: ≥ 4

Endocrine System

Young Adult Population:

Males see significant increases in testosterone.[4] Males demonstrated beneficial gene expression, increase in GASP-1 and SMAD-7 expression and diminished MSTN expression.[12] Increased lactate levels with cuff at proximal thigh and arm.[20, 21] Decreased intramuscular pH and PCr suggests beneficial metabolic stress in males.[22] All study procedures placed cuff at proximal thigh unless specified.

Older Adult/ Geriatric Population:

Males demonstrated improvements in serum GH.[28] Improved bone ALP concentration and ALP/ CTX ratio observed with males.[11] No change in serum triglyceride, HDL/ LDL, total cholesterol, and glucose/ HbA1c levels meaning low risk to cardiovascular health in males.[32] Males' increased norepinephrine and lactate concentrations suggest healthy cardiovascular adaptations.[28] Conflicting research demonstrates no increase in serum testosterone, IGF-3, and IGFBP-3 in males.[9] All participants performed training with cuff placed at proximal thighs; additional trial with cuff at proximal arm.[28]

Psychosomatic System

Cuff placed on proximal arm:

Ratings of perceived exertion (RPE) were found to increase with the use of BFR training, but to a lower extent than traditional HI-resistive exercise.[15,20,34] RPE was also shown to decrease over time with use of BFR training,[15] and was specifically decreased in intermittent BFR compared to continuous BFR.[20] Discomfort ratings in the UE decreased over time with use of BFR.[15]

Cuff placed on proximal thigh:

RPE and overall pain values increased with BFR, but to a lower extent that HI-resistive exercise.[14,15] BFR was found to have a negative effect on total mood state, total mood disturbance, and participant fatigue.[29,30]

Cardiovascular System

Young Adult Population:

Resistance training with BFR in young adults was found to elicit similar responses in SBP,[18,19] DBP,[18,19] and blood flow[19] to high intensity resistance training, however HR response was decreased.[24] BFR was also found to maintain carotid artery compliance compared to high intensity resistance exercise.[24]

Low intensity aerobic exercise combined with BFR in younger subjects was found to increase VO2 Max significantly more than traditional aerobic exercise at higher intensities,[7,17,21] or produce similar improvements in VO2 Max.[25] At lower relative intensities cardiac responses were found to be greater than traditional aerobic exercise when comparing HR,[10,25,26,31] central blood pressure,[31] and peripheral blood pressure,[26] but similar effects on cardiac output.[26,31] A negative effect was found for endothelial function following aerobic exercise with BFR.[26]

Older Adult/ Geriatric Population:

In adults older than 50, one study showed no difference in HR, SBP, DBP, ABI, or Flow Mediated Dilatation responses between low intensity training with BFR and traditional resistance training.[34] BFR increased arterial stiffness in the lower extremity when compared to the contralateral exercising limb.[5] BFR was found to improve vascular endothelial function and peripheral blood circulation.[28]

Aerobic exercise combined with BFR in healthy older adults was found to improve VO2 Peak[13] but not VO2 Max[1] more than traditional aerobic exercise. Cycle ergometry with BFR was found to improve exercise capacity compared to traditional aerobic exercise in patients with CHF[32] and ESRD.[3] Maximal Venous Outflow and Venous Compliance were significantly increased.[8] One study found carotid artery compliance improved with BFR compared to traditional walk training.[23]

Four studies provided occlusion at the proximal upper arm,[18,19,24,35] while 14 provided occlusion at the proximal thigh,[1,3,5,7,8,11,13,17,21,23,25,26,31,32] and one study providing occlusion at the proximal upper arm and proximal thigh in alternating fashion.[28]

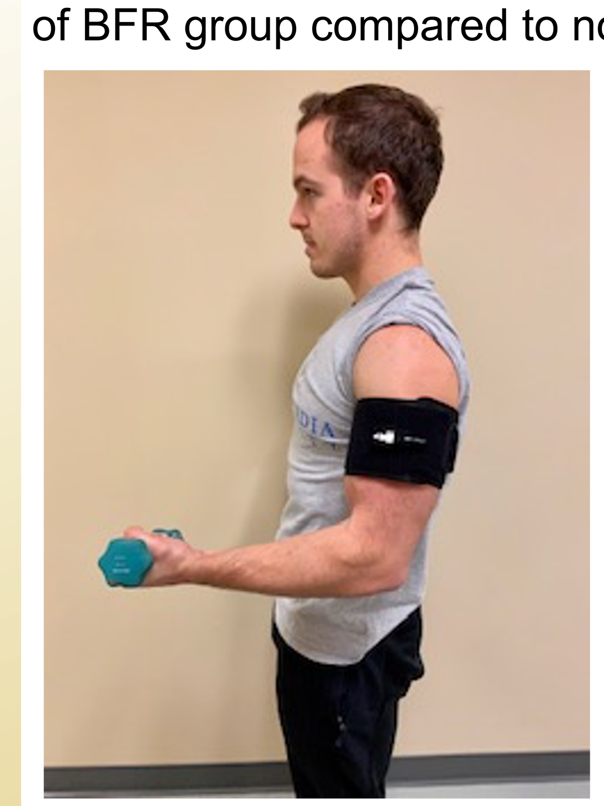
Systemic Musculoskeletal

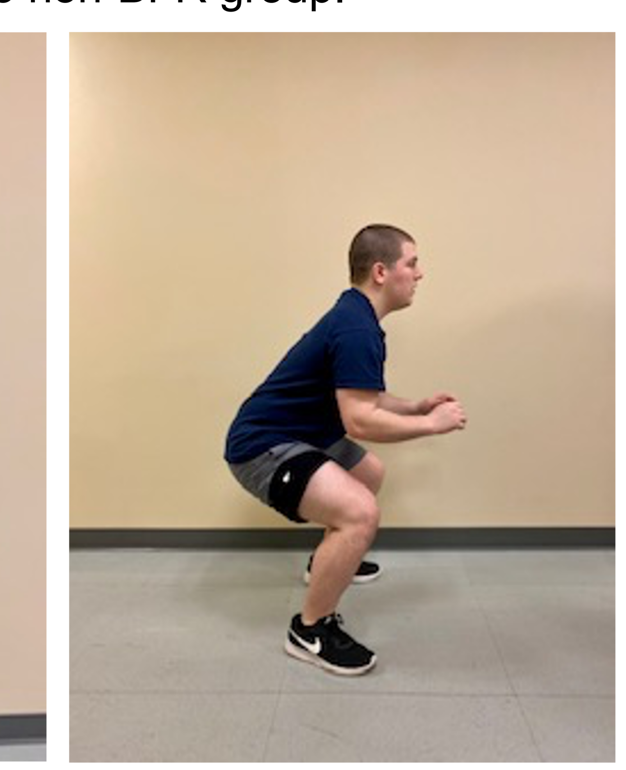
Cuff placed on proximal arms:

With bilateral proximal upper arm occlusion, findings demonstrate increase in muscle thickness of pectoralis major and bench press 1-RM compared to non-BFR groups.[35] Other findings suggest similar increases in pectoralis major hypertrophy and bench press,[24] row, and overhead press strength between both BFR and non-BFR groups, but BFR groups worked with a reduced load.[33]

Cuff placed on proximal thigh(s):

With bilateral proximal thigh occlusion, there is evidence of significant increases in bench press 1-RM strength compared to non-BFR groups.[4] With walking training, there was no difference in gluteus maximus and L4-L5 muscle hypertrophy between groups.[27] When only training one arm, similar increases in upper extremity hypertrophy between groups were noted, but there was a greater increase in upper extremity strength of the untrained arm in the BFR group compared to the non-BFR group.[16] With unilateral proximal thigh occlusion, findings demonstrate greater increase in thigh girth and knee extension strength in contralateral lower extremity of BFR group compared to non-BFR group.[2]





Limitations

Limitations include: non-standardized procedures and application parameters/ dosing, diverse patient demographics, lack of disease-specific research, and potential conflicts of interest.

Conclusion

BFR demonstrates systemic effects on multiple body systems, and although the reviewed literature gives specific examples of improvements and/or detriments to those utilizing the intervention, the overall effect remains unclear due to a widespread range of populations and dosing parameters.

Further research should investigate the appropriate dosing parameters, including ideal cuff width, pressure, and duration of partial occlusion. Future studies should also attempt to investigate effects on specific patient populations (elderly, medically compromised, etc.) who stand to benefit the most from this intervention.

References available upon request

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